Moving NASA/MSFC towards a more Model-centric Organization

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Agenda

- Introduction
- Community of Interest
- Maturity Matrix
- Sampling of Activities

Introduction

- **MBSE is much broader than a single modeling approach or tool**
  - There are many tools needed to develop a full system model
    - Tools to integrate and view system information
      - SysML Editors (MagicDraw, Enterprise Architect, etc.)
      - Alfresco
      - Doors, Cradle, Core
      - Sharepoint
      - Syndia
      - Windchill, CREO
      - CAMEO
    - Tools to model different perspectives of the system
      - Matlab, Mathcad, Mathematica provide an approach for physics based system modeling, Multidisciplinary Design Optimization (MDO), System Value Modeling
      - Matlab/Stateflow provides an approach for state analysis models
      - Microsoft Excel for large data set capture
      - Anylogic, ExtendSim for Discrete Event Simulation (DES), System Dynamics models, Agent Based Models (ABM)
- **MSFC is investigating**
  - MBE Architectures
  - Set of System Modeling approaches to fully represent the system

MBSE Community of Interest

- **Includes Practitioners and Interested Parties**
- **Proposed Activities**
  - Catalog on-going and proposed MBSE efforts
  - Gather (Stakeholder) Needs/Expectations
  - Share knowledge, issues/problems, solutions, lessons-learned, &c.
  - Tutorials & Lunch-and-Learns
  - Case Studies
  - &c.

MBSE/MBE Maturity Matrix

- **Approach:**
  - Identify/Decompose characteristics/factors that describe/comprise a fully model-centric organization's capability
    - Rows: Broad range of factors/attributes that directly or indirectly support/enable MBSE/MBE
      - Workforce/Culture
      - Processes/Methodologies
      - Tools & IT Infrastructure
      - Project Use
      - Policy
    - Columns: Increasing Levels of Maturity
- **Characteristics:**
  - Right-most column reflects fully mature MBSE/MBE Capabilities
  - Each row reflects increasing levels of capability for that specific factor/attribute
- **Features:**
  - Provides a strategic vision to guide tactical planning
  - Able to track progress cell-by-cell
  - Easy to see what factors/attributes are being worked
  - Easy to status work underway, complete, planned
  - Able to plan/prioritize future efforts cell-by-cell

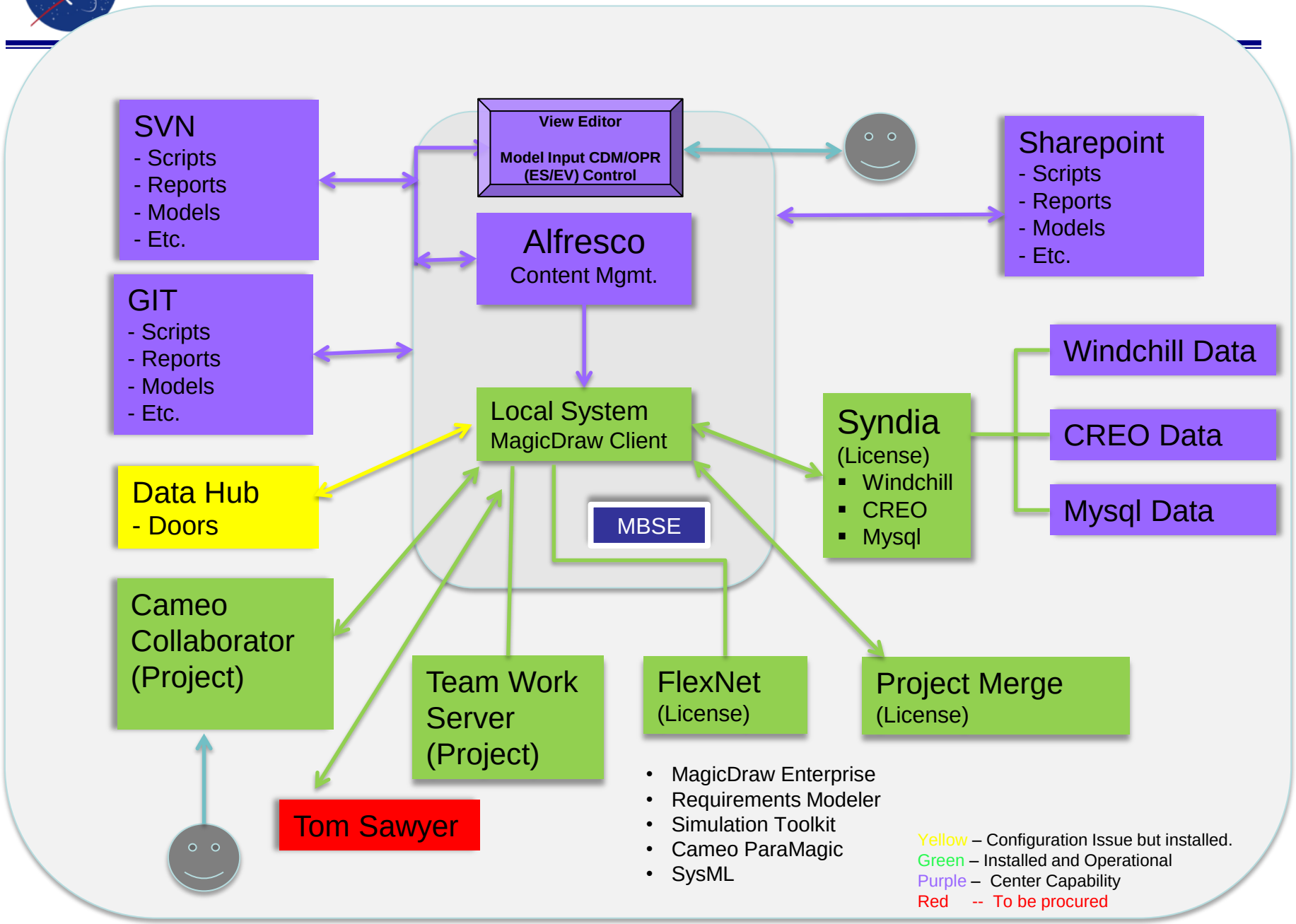
MBSE Maturity Matrix (Draft)

MBSE Maturity Levels	Level 0	Level 1	Level 2	Level 3	Level 4	Commentary
Workforce/Culture						
MBSE Approach/Objectives	Awareness	sub-Discipline Tool use (e.g., CRADLE, DOORS)	Full System Models. Modeling results used to inform systems engineers in system analysis, design, and integration.	Full System Models; Model views translated into more traditional views for use and understanding by organization. Modeling results support decision making.	Full System Models; Organization familiar and competent in using modeling views for key system decisions	MBSE Approach/Objectives are well defined and broadly communicated to, and understood by, Engineering, Program/Projects, CIO, S&MA, etc.
Tool Use	Limited	Partial, Standalone	General use of specific model(s) within System Engineering organizations.	General use of specific model(s) within Systems Engineering organization with understanding how external systems engineering models related.	Multiple, Heterogeneous	Expecting different tools to be used intra/inter-Center, between Gov and Contractor, and across Contractors
Modeling Skills	Novice	Training on Sub-Discipline Tools	Expert Modellers on full suystem models.	General training of systems engineering workforce on use of full system model results.	Expert	More than just modeling tool expertise. This includes expertise in model structure/architecture that supports all subsequent uses
SE-driven Model Building	None	sub-Discipline Models (e.g., CRADLE, DOORS)	Full System Models.	Multiple System Models	Mature/Complete	Model structure/architecture driven by SE objectives/analyses/uses and evidentiary artifacts
Lifecycle Coverage	Limited	Single Phases	Multi-Phases; Limited Reviews	Multi-Contiguous Phases	End-to-End, Top-to-Bottom	Across all Phases and down to lowest decomposition
Level of Institutionality	Scattered Pockets	Consistent with Systems Engineering Organizations. Varies among organizations.	Common basis across Center. Varied used within organizations and projects.	Consistent Center approach across organizations with variations as appropriate for specific system needs.	Center/Agency Wide	Tools, training, and IT infrastructure provided/maintained by Institutional resources
Training	Intro 101	Modeling	SE-Driven Model Building	Mutliple Sysem Tools	Integrated Curriculum w/ Practical Experience (Case Studies)	Multilevel training series, including "hands-on" real world(-like) execution
Processes/Methodology						
Artifacts	Docs	Documents incorporate model generated views.	Docs; Model Views	Viewpoints defined	Various Media (Views) drawn from Model(s)	Defined, standardized viewpoints auto-populated from model(s). Implies model(s) are structured/architected to support these viewpoints
CM/DM/VM	Doc-managed;	Doc- managed; Generated from Model(s)	Doc-managed; Synced to Model(s)	Model-managed	Model-managed; defined/standard Viewpoints; Integrated/Coordinated Governance Structure(s), automated workflow and routing	Models/Databases are managed (vice Docs/drawings); Viewpoints reflecting SE and user objectives/analyses/needs are defined and standardized; Governance structures (e.g., Change Control Agents) are integrated and coordinated; Workflows and routing are defined, standardized, and automated
Milestone Reviews	Docs-based	Doc-based	Doc-based; Model Driven	Doc and Model Reviewed (mixed)	Model-based Review; structured, Objective-driven Viewpoints	Reviews are completely model-based (I.e., no docs/dwgs); Evidentiary artifacts include defined/standardized viewpoints that can be auto-populated from disparate, heterogeneous, models and databases
Modeling Methods	Unstructured	Various, semi-structured	Best Practices evolving; Patterns emerging	Best Practices converged; Patterns being captured, reused	Structured; Reusable patterns/models/components	Modeling methods driven by SE objectives/analyses/uses and evidentiary artifacts, includes Library of standardized and frequently used patterns/models/components
Tools & IT Infrastructure						
Tool(s)	Reqts Mgmt, XL	Full Systems Models applied variously across Systems Engineering organizations.	Consistent within separate Systems Engineering Organizations.	Center-wide license access for commonly used tools	Agency-wide license access for commonly used tools	Tools, provided/maintained by Institutional resources
Collaboration	E-mail, telecom.	System Model File Exchange.	Various organiations working on different parts of model. Full model integrated by a single organizations.	Partial On-line, real-time collaboration amongst distributed teams	On-line, real-time collaboration amongst distributed teams	Synchronous and asynchronous data-rich collaboration among distributed teams
Data Structures	System terminology defined.	Common Glossary/Data Dictionary	Top Tier Ontology	Discipline Ontologies	Common, tiered taxonomies/ontologies	A hierarchy of taxonomies and ontologies: Generic Upper Level with subordinate domain/discipline Lower Levels
Disparate DB/Tool interoperability	None	Tool-to-Tool, ad hoc interoperability	Partial FDBMS	Main tools interoperable. Supporting tools interact through file transfer.	Fully Federated w/ standard "plug-and-play" interfaces	A fully Federated (or Confederated) data and IT infrastructure that functions as one virtual common database. Includes a standardized interface(s) for other data sources to join the Federation (APIs, wrappers, etc.)
Inter-DB/Tool Data Item Association	None	Associations defined	Associations defined, captured, managed	Associations defined, captured, managed	Associations among all data items defined, captured, managed, and traceable	Capture and manage associations between data items within and between disparate data sources. Associations can be traced between data items regardless of their location.
User IF, Viewpoint/Views	N/A	Doc Gen	UI draws from Model app	UI draws from multiple models/DBs	UI supports Interrogation; multiple configs	Viewpoints reflecting SE and user objectives/analyses/needs are defined and standardized; Supports interrogation, navigation, tracing, etc. of data from disparate, heterogeneous data sources
Project Use						
Type	4,5	3,4,5	2,3,4,5	2,3,4,5	All Types	Used by all Categories, Classes, Types of P/P/As
Size	Small. Stand alone.	Small to Medium. Stand alone and sub-system portions of larger systems.	Small to Large (not Programs). Stand alone and sub-system portions of larger systems.	Small to Large (not Programs). Stand alone and sub-system portions of larger systems.	Scaleable to all sizes	Scalable and/or Tailorable to all sizes of P/P/As
Policy						
Reflection in MPR(s)	Not Prohibited	Model results called out explicitly as products.	Basic modeling characteristics identified.	Model-based infrastructure reflected.	MPRs recast to reflect model-driven processes and model-based artifacts (e.g., entrance/success criteria based on process objectives as reflected in the views/viewpoints, not doc creation)	MPRs recast to reflect model-driven processes and model-based artifacts (e.g., entrance/success criteria based on process objectives as reflected in the views/viewpoints, not doc creation)
Contractual Mechanisms/Language	Doc-Based	Some information delivered as models.	Information delivered as models.	Information delivered as models.	SOWs, DRDs based around model/DB exchange and/or access; Underlying processes aligned with new capabilities to meet objectives	SOWs, DRDs based around model/DB exchange and/or access; Underlying processes aligned with new capabilities to meet objectives

MSFC "Prototype" Open MBEE Architecture –

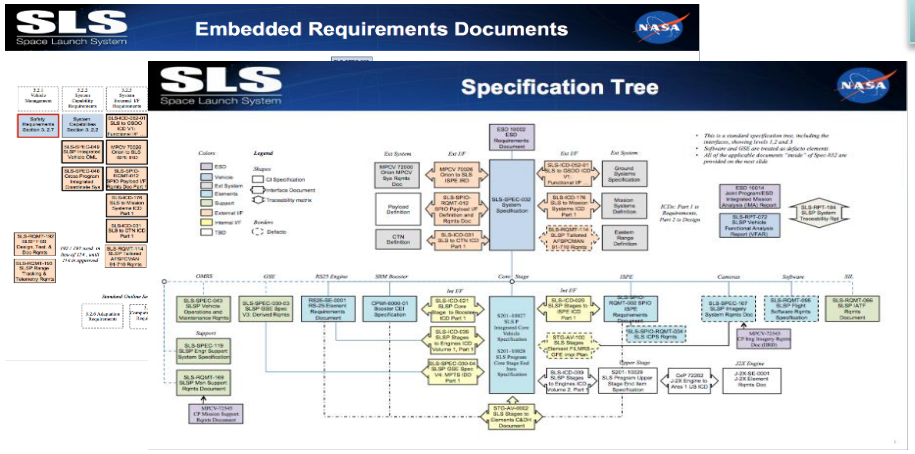
Equivalent to JPL Model

MSFC model includes Cameo Collaborator, Project Merge, Syndia for integration to Windchill/Creo Data



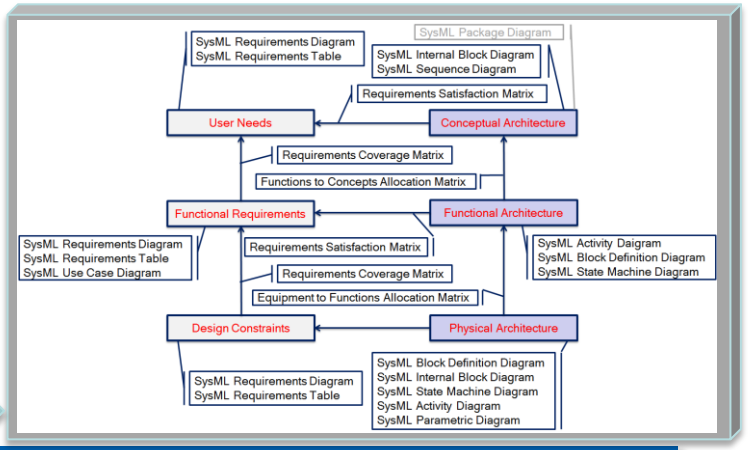
SLS/Europa Interface Requirements Model

- Develop and demonstrate the Model Based Systems Engineering (MBSE) approach for SLS/Europa Interface Requirements Model (IRM) for systems engineering functions in the Model Based Engineering Environment (MBEE)
- **Result to date:**
  - Modeled the Secondary Payload Interface requirements Document Template; In the process of completing the cross references
  - Integrated JPL Europa Launch Vehicle System Model into the local MBEE instantiation
  - Demonstrate functionality of the MBEE architecture and train users (SE's, SE Modelers, etc.)



Replaced By

SysML Mission Model



User Defined Views

MODEL BASED CONCEPTUAL AND FUNCTIONAL REQUIREMENTS, ICD'S, CONSTRAINTS, & SPECIFICATION INFORMATION, BECOMES INTEGRATED RELATIONAL, AND INTUITIVELY ACCESSIBLE THROUGH DIAGRAMMATIC AND DOCUMENT-BASED VIEWS

Secondary Payloads (planned)

Implement MBSE with a secondary payload to compare and contrast traditional SE approach with model based. Goal is to be able to interface with future payload providers digitally

- **Objectives:**
  - Use payload managed out of MSFC – NEA Scout
  - Model physical and safety interfaces to SLS
  - Run model in parallel with traditional methods for comparison
  - Model used to generate SRR SE products
  - Build model libraries for reuse

Software Provisioning in the Cloud

Software Cloud Provisioning Pilot Objectives:

1. Demonstrate MagicDraw® license management capability in the NASA "cloud" environment
2. Demonstrate the potential for enhanced engineering collaboration by multiple NASA centers within the cloud

Results to Date:

- This first of kind "proof of concept" pilot successfully achieved its purpose by confirming the ability to provision a software tool and the ability to share models across NASA centers within the cloud environment
- Identified the complexities of agency wide firewall access and basic functionality
- Fortified the collaboration and partnerships between OCE and OCIO
- Successfully Deployed Software Usage Monitoring Capability
- Successfully Tested out the NAMS process to authorize licenses
- Successfully deployed capability Agency wide. In FY16 capability utilized to support MBSE Pathfinder